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MDA Update

Linking American Businesses to Missile Defense Technology

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Countering Terrorism with Technology —by Tabatha Spitzer

Innovations in chemical detection, imaging, and pattern recognition can help strengthen our defenses against future attacks.

The September 11 terrorist attacks created an international outcry for answers on why and how the tragedy could have happened, especially in the most technologically advanced country in the world. Many people blame technology—either that it failed us or it enabled the spread of terrorism through better communication abilities.

Ari Fleisher, White House spokesman, said “It’ll be quite a while before the United States is at the lowest [threat] level—time, technology, and terror are not on our side.”¹ Technology needs to be on the right side again.

The Ballistic Missile Defense Organization (BMDO), now Missile Defense Agency, has been funding some of the most innovative technologies in missile defense today. Some of the technology—in the areas of chemicals detection, imaging, and pattern recognition—could help counter future terrorist attacks. Three examples are featured below.

Ultraspectral Imager

It’s no secret that a chemical attack would devastate a highly populated area. A study

by the U.S. Army surgeon general shows that mid-range casualty estimates from a chemical weapons attack or toxic chemical manufacturing plant explosion are as high as 903,400 people.²

There are four major categories of chemical agents, according to the National Library of Medicine’s Specialized Information Services. Each category contains chemicals that can cause harm in as little as 1 minute to 24 hours, depending on the chemical. In some cases, emergency response teams may have no more than 15 minutes to determine the type of chemical and administer medical care. After that, treatment can be futile. Therefore, it is imperative that the chemicals be identified quickly.

Kestrel Corporation (Albuquerque, NM) has developed an ultraspectral imager capable of detecting most solids, vapors, and aerosols by their molecular absorption spectra over a very wide range of the infrared spectrum (both 3 to 5 microns and 8 to 12 microns) in near real-time. The BMDO SBIR

program funded Kestrel to develop a system that would identify a missile by the chemical composition of its emissions, know its full capabilities, and develop intercept procedures.

The imager is a nonintrusive monitoring system that can identify contaminants on a surface or in an airborne cloud. The sensors can work



Image courtesy of FEMA

Terror hits home. The complete destruction of the World Trade Center Towers and the attack on the Pentagon alerted Americans to their vulnerability to terrorism and signaled the need for a strong homeland defense backed by innovative technology.

as passive remote observers or, with an active illumination source, they can observe infrared molecular absorption or emission signatures with their spatial distribution. The imager is a turnkey technology that is electrically cooled,

Continued on page 14

¹2002. Ridge Unveils New Alert System. Associated Press, March 2.

²Pianin, Eric. 2002. Study Assesses Risk of Attack on Chemical Plant, Washington Post, March 12.

Editor

Patrick Hartary

Production Manager

Lisa Hylton

Graphics

Lan Crickman

Contributing Writers

Adam Gruen, Patrick Hartary,
Tabatha Spitzer

Advisors

Bill Meyer, Jeff Reynolds,
JR Shasteen, Duane Zieg

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Please address inquiries and mailing list corrections to:

National Technology Transfer Center-Washington Operations

2121 Eisenhower Avenue, Suite 400
Alexandria, Virginia 22314

Attn: Editor, *MDA Update*

Tel: 703-518-8800 x500

Fax: 703-518-8986

E-mail: pat@nttc.edu

Web sites: www.acq.osd.mil/bmdo/bmdolink/html/transfer.html
www.mdatechnology.net

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FROM MISSILES TO TERRORISTS

Countering terrorism has become a national priority. So much so that President Bush is asking Federal agencies that operate Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs to look at the technologies they funded to see if any could be used by law enforcement agencies.

Could missile defense technology give law enforcement and others involved in counter-terroring terrorism an edge? Yes, it could. Here's how.

The Ballistic Missile Defense Organization (BMDO), now the Missile Defense Agency (MDA), has funded some of the most advanced technologies in the areas of computing, imaging, and sensing through its SBIR and STTR programs. While these innovations were initially designed to improve missile defense, they also have great potential to help identify chemical agents used in terrorist attacks, spot potential terrorists in crowded areas, and track money laundering activities that support terrorist operations.

Consider, for example, hyperspectral imagers. MDA is interested in these devices to detect and track incoming enemy missiles in a cluttered background. But the technology could also be used to analyze and identify the type of chemical(s) used in a chemical terrorist attack. Early chemical identification would help responding emergency teams to know how best to treat the injured at the scene and how far away to set up a containment area.

The MDA Technology Applications program has developed a special report that describes more examples of BMDO-funded technology with counter-terrorism applications. To obtain your free copy, go to page 15 and follow the instructions in the shaded box.

Opening Doors

For the *MDA Update*, success comes when we make connections between companies developing MDA-funded technology and organizations interested in using or commercializing it. So I'm pleased to report our most recent success.

In the Winter 2001/2002 issue, the *MDA Update* featured Electron Power Technologies' novel approach to energy storage involving ball lightning, a rare and unexplained natural event that produces a glowing ball of energy lasting for a few seconds. Clint Seward, the inventor, had presented this technology to several organizations, but he wasn't having any luck with the Department of Energy (DOE). "I had been trying to speak with someone at DOE for over 10 years," explains Seward. "But right after the *MDA Update* article was published, DOE contacted me. They wanted to know more about the technology featured in the article."

Patrick Hartary
pat@nttc.edu

CORRECTION

In the Spring 2002 *MDA Update*, the unit of measurement in the third paragraph on page 7 should be μm , not m.

WORKSHOPS HELP RESEARCHERS FOCUS ON BUSINESS

One of the greatest challenges for researchers in small, high-tech companies is focusing on strategic goals. In the laboratory, researchers can often become so concerned with their technology's development that business issues are not addressed, thus reducing the chance for success in the marketplace.

Business Focus Workshops (BFWs) help MDA-funded researchers get a head start on the path toward commercialization. The BFW is a significant element of MDA's Technology Applications (TA) program, which is administered by the National Technology Transfer Center-Washington Operations (NTTC-WO). All Phase I Small Business Innovation Research (SBIR) awardees are invited to attend a BFW.

In a BFW, a representative of the company is teamed with a business consultant and an engineer/facilitator from NTTC-WO. In the first part of their session together, the consultant and facilitator ask questions to better understand the company's SBIR concept and its strategic vision. Typical questions include:

- Where does your company ultimately want to be in 5 to 10 years?
- Can you identify specific technical milestones beyond Phase I?
- What are the applications of your technology and the key market advantages for each?

- Who are the competing companies and what are the competing technologies?
- Who are the biggest players in the market?
- What is the shortest time it would take to get to a first product and how much money would it take?
- What are at least three key milestones (technical- or business-related) that need to be reached in the next 3 to 5 years?

Once the basic questions have been asked and the necessary information collected, the consultant leads the team in creating the basic structure of a business plan. This plan includes preliminary descriptions of the product or service, its market applications, estimates of market size, and potential first customers. In addition, the company's planned business model, required resources, technical milestones, and a timetable for product development are estimated.

After this exercise, the basic structure of the business plan is presented to the other BFW attendees. Then, the company representative is asked questions and offered advice from those people not directly involved with him or her in the morning "team" session.

In 2001, 35 companies attended BFWs. As in the past, these meetings proved to be very valuable for most attendees. The following comments were taken from evaluation forms submitted from company representatives:

■ "This is a wonderful workshop. It helped me think more on business planning, intellectual property protection, and market analysis."

■ "I felt the workshop was a great success and well worth the time invested."

■ "The exercise in developing a 5-slide/10-minute presentation of the business plan was excellent."

Overall, the BFW provides an intense educational experience for the company representatives and often succeeds in redirecting some of their attention toward the business aspects of technology development and commercialization. For those MDA-funded companies interested in attending a BFW, please sign up for upcoming meetings at www.mdatechnology.net/signup/.



Lending an ear. In MDA-sponsored workshops, experts listen to researchers' presentations and give advice and potential business contacts.

BFWs help commercialize SBIR technology. Successful commercialization allows this technology to survive and mature to a level where it can be reliably used, cost-effectively solve a problem, or satisfy a requirement in an MDA system.

Attention Researchers

Want to be featured in the MDA Update? If your company is developing an MDA-funded technology that has strong commercial potential, call editor Patrick Hartary at (703) 518-8800, ext. 222. We can help spread the word about your innovation to the media, large commercial businesses, venture capitalists, associations, and other government agencies.

PULSED LASER DEPOSITION PROCESS PRODUCES HIGH-QUALITY THIN FILMS AT HIGH RATES

Those in pursuit of high-quality thin films face a dilemma when choosing a fabrication method. Chemical vapor deposition (CVD) offers high deposition rates, but often requires expensive precursors, uses high temperatures, and produces undesirable byproducts. Physical vapor deposition (PVD) is much cleaner, yet deposition rates are typically lower than for CVD. Also, many materials, such as oxides, cannot be efficiently deposited using PVD methods.

With BMDO SBIR funding, AMBP Tech Corporation (Amherst, NY) has developed another option: laser-assisted molecular-beam deposition (LAMBD). This method can be used to create uniform, high-purity thin films from 50 angstroms to 10 microns with very flat morphologies.

LAMBD is a reactive process that simplifies the production of complex films such as carbides, nitrides, and metal alloys. These films have many applications in the microelectronics industry, including metal-oxide films and silicon-on-insulator (SOI) devices, which are needed for next-generation electronics. In particular, SOI technology offers many advantages for BMDO applications, such as high speed, low voltage/power, radiation tolerance, and high-temperature operation. In addition, LAMBD can

be used to create buffer layers for superconducting tape, an emerging technology with many electric power applications.

Similar to pulsed laser deposition, the LAMBD source uses a laser to rapidly heat a target causing a cloud of evaporated target material to be generated. This cloud is simultaneously combined with a pulse of reactant gas, often oxygen or nitrogen. The ablated target material and the gas form a unique chemical reactor from which nanoparticles can be generated or from which films can be deposited. For example, a titanium or gallium target rod can be used along with nitrogen to create titanium nitride or gallium nitride films.

The product molecules are expelled from the pressurized LAMBD source into a vacuum chamber, where they are deposited on the substrate. With each pulse, a known amount of material is deposited. By adjusting the laser power, the amount of

material deposited by each pulse can be varied, while regulating the total number of pulses used in the deposition process allows precise control of film thickness. Typical deposition rates are on the order of hundreds of angstroms per minute.

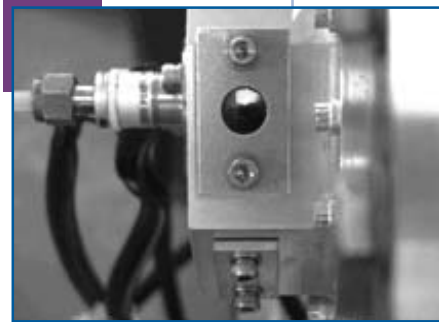
Because the product materials are accelerated toward the substrate only by the pressure difference between the LAMBD source and the deposition chamber, their kinetic energy levels are low, reducing the potential for substrate damage. Additionally, the ability to focus the laser beam only on the target material results in very low levels of contamination.

A prototype system with a 3-inch wafer capability has been developed. Work has begun on finding ways to spread material over larger areas, with the goal being first 8-inch and then 12-inch wafers. In the meantime, AMBP Tech would like to license the technology while making films, coatings, and nanoparticles as a service. To further commercialization efforts, the company seeks additional partners, personnel, and funding.

—P. Hartary

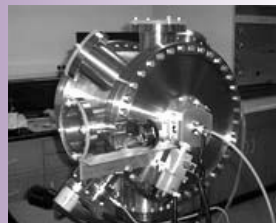
CONTACT INFORMATION:

Dr. James Garvey
AMBP Tech Corporation
1576 Sweet Home Road
Amherst, NY 14228
Tel: (716) 639-0632
Fax: (716) 639-0632
E-mail: sales@ambptech.com
Web: www.ambptech.com



Plasma portal. Through a small window in the deposition tool, operators can view the plasma plume created by the laser ablation pulse focused down on a target metal surface.

In a related BMDO-funded project, AMBP Tech demonstrated the viability of a pulsed-arc technique similar to its laser-assisted deposition process.



Save \$20 million. The LAMBD source is adaptable and can be used alone or in tandem with existing deposition equipment.

BIG YIELDS FOR SMALL POWDERS

Nanotech swords into plowshares: pulsed plasma technology used for guns and launchers has now been turned towards mass production of very fine, nearly perfect metallic powders.

With BMDO funding, UTRON, Inc. (Manassas, VA), developed and patented a working pulsed plasma atomization device that uses ionized argon gas to form molten lead-tin alloys into nanosized (5- to 15-micron) powders, with a yield at least twice that of traditional gas atomizers. The electronics industry needs these fine powders to solder components together on circuit boards with ever-shrinking trace widths.

The pulsed plasma technology used today was originally funded by SDIO in the 1980s for potential use in high-energy weapons systems. In 1996, BMDO awarded UTRON an SBIR Phase I contract to develop a cheaper way to produce nanosize aluminum powder for use in advanced solid rocket propellant. The company proved the concept and in 1998 BMDO funded Phase II research to see if pulsed plasma tech-

niques could be used to produce nanosized copper for metal injection molding and iron nanopowders for low-mass radar absorption coatings. However, UTRON engineers achieved only partial success: the ceramic crucible that controlled the molten stream was being destroyed by high temperature chemical incompatibilities.

Hoping to find a market for pulsed plasma atomization, UTRON later turned to the idea of producing 5- to 15-micron-sized (Type 6) lead-tin powders for the circuit board industry. The softer metals could be heated at low (400 to 500°F) temperatures and did not destroy the crucible.

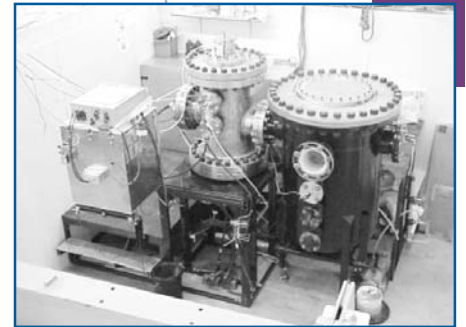
The secret to the higher yield of UTRON's pulsed plasma atomizer is pulsed, high-pressure capillary discharge powered by electric arcing. In effect, a very tiny rocket engine exhausts argon at a velocity equivalent to several kilometers per second. Particles in the melt stream are thus "atomized" and thrown out with such momentum that more of them cool into nearly perfect spherical shapes. Traditional techniques

might only produce 10 to 15 percent of a desirable size and the rest must be discarded; high momentum flux can double the yield to 30 percent or more.

With private investment capital, UTRON is building a new facility to house an oxygen-free nanopowder production model of the atomizer. Oxygen content is the enemy in the solder paste industry, which demands 100 parts-per-million or less. The company has a contract to supply oxygen-free samples of Type 6 lead-tin powder to a major solder paste manufacturer.

Ultimately, UTRON hopes either to license its technology or enter into a joint venture arrangement. Beyond the electronics industry, pulsed plasma atomization techniques could be used to supply powders for metal injection molding and perhaps even produce polymer powders. The company invites inquiries from interested parties who might have needs and applications for nanopowders.

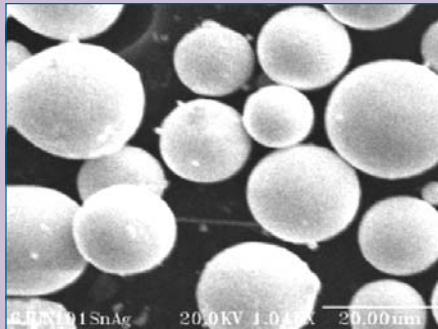
—A. Gruen



Steady pulse. UTRON's pulsed plasma atomizer is derived from technology developed for high-energy weapons systems.

The secret to the higher yield of UTRON's pulsed plasma atomizer is pulsed, high-pressure capillary discharge powered by electric arcing.

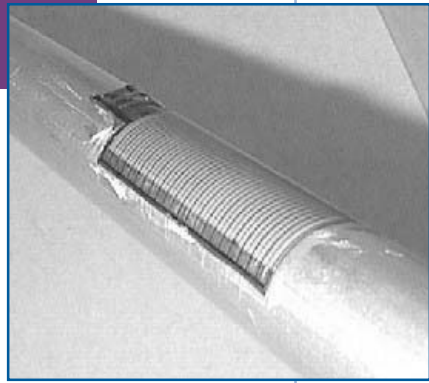
Nano shot. Lead-tin alloys are melted and then cooled so rapidly that they don't have time to form odd shapes.



CONTACT INFORMATION:

Dr. F. Douglas Witherspoon
UTRON, Inc.
8506 Wellington Road, Suite 200
Manassas, VA 20109
Tel: (703) 369-5552
Fax: (703) 369-5298
E-mail: fdwitherspoon@compuserve.com
Web: www.utroninc.com

PIEZOELECTRIC DEVICES: SHAPING UP



Conformable. Midé's PowerAct® transducer technology can be mounted to cylindrical shapes like this one-inch-diameter pipe.

Midé is marketing PowerAct® transducer technology for structural actuation and sensing applications.

Ceramics are brittle, difficult to machine, and only available in ordinary shapes like rods, sheets, wafers, and tubes. When developing new ceramic-based piezoelectric transducers (e.g., actuators and sensors), these problems severely limit designers' options. Tiny grooves will help designers to create more

flexible geometric designs when working with electroactive ceramics. Midé Technology Corporation (Medford, MA) is using inexpensive laser-based machining (LBM) to create small channels in flat ceramic plates. These channels provide strain relief when the plates are bent, allowing transducer devices to be formed into complex geometric shapes such as domes, spheres, and cylinders.

Because the LBM process is so flexible, conforming ceramics to virtually any desired shape is possible. For example, parallel grooves will allow devices to conform to cylindrical surfaces, while concentric grooves yield devices for spherical surfaces. Multidirectional grooves are also possible. Devices incorporating multidirectional grooves not only conform to complex shapes, they offer multidirectional behaviors. Picture an actuator that not only bends, but twists.

LBM is implemented with a neodymium-yttrium-aluminum-garnet laser using

variable power and pulsing to control the width and depth of the material cuts. Scanning mirrors are used to precisely deflect the laser's beam and control its position on the ceramic surface to within less than 0.001 inches. The laser has a standard beam width of 0.004 inches, which can be adjusted to as low as 0.001 inches. Forms with features on the order of 0.002 inches in size and curves with a radius of 0.002 inches are achievable.

After creating the desired electroactive ceramic shape, thin copper electrodes are formed on a polyimide film and bonded to the ceramic. These electrodes are used to create the electric field required to cause the desired dimensional changes in the ceramic. Midé can fabricate electrode configurations that efficiently produce the desired dimensional changes in the ceramic material.

LBM is particularly useful in developing piezoelectric devices such as actuators and sensors. These devices have a wide range of applications, including noise, vibration, and shape control as well as strain and health monitoring within materials and structures. For BMDO, which funded the development of LBM through its SBIR program, the technology would be invaluable for applications such as vibration control, which is needed in aerospace structures and vehicles.

In a related project also funded by BMDO, Midé is exploring the use of stacked piezoelectric actuators to har-

ness energy from structural vibrations (e.g., in a ship's propeller or a helicopter's blade) and store it in thin-film lithium-ion batteries embedded into a composite structure. The technology would be ideal for self-powered remote sensors and emergency equipment, such as beacons and telephones.

Commercialization efforts are well underway. Midé has introduced their PowerAct® transducer technology for structural actuation and sensing applications. To date, the company has provided samples to Lockheed Martin Astronautics (for precision shape control of deployable structures), European Aerospace and Defense (for active noise control), Ohio State University (for adaptive antenna shaping), and Boeing Helicopter (for active vibration control in rotocraft blades). Midé seeks additional companies and military organizations interested in exploring potential applications for its transducer technology.

—P. Hartary

CONTACT INFORMATION:

Dr. Marthinus van Schoor
Midé Technology Corporation
200 Boston Ave, Suite 2500
Medford, MA 02155
Tel: (781) 306-0609
Fax: (781) 306-0619
E-mail: tienie@mide.com
Web: www.mide.com



THE FUTURE MAY HINGE ON ELASTIC MEMORY COMPOSITES

Take a shape memory polymer, reinforce it with fiber, and you've created the basis for a device capable of gently lifting 30 times its weight against gravity.

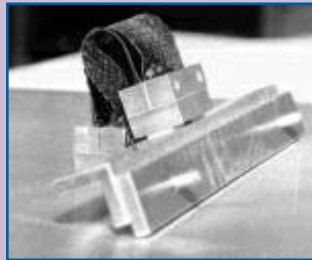
With the help of BMDO, NASA, and NRO funding, Composite Technology Development, Inc. (CTD; Lafayette, Colorado), has developed a new kind of elastic memory composite (EMC) that is one-fifth as dense as shape memory alloys and delivers more force than shape memory plastics. Spacecraft designers can use EMC in hinges as a lightweight means of unfolding solar arrays and antennas in space without motors or springs.

In a BMDO SBIR Phase I contract begun late in 2000, CTD had a relatively simple objective of replacing with EMC the smart metal alloy used in the hinges of the Air Force Research Laboratory's Lightweight Flexible Solar Array. The results were encouraging: EMC lifted the same mass as the metal could, but weighed only half as much. In a Phase II contract awarded in 2001, CTD is working to cut the total weight of the whole hinge by 50 to 80 percent.

CTD engineers have done for shape memory polymers what 19th-century engineer Joseph Monier did for steel-reinforced concrete. They determined how to reinforce shape memory polymers with fibers to provide a dramatic increase in stiffness and strength while accommodating

much higher strain. EMC is a thermally activated smart material. It can be heated, deformed, and then cooled to maintain a new shape. It recovers its original form with the subsequent application of heat. An added benefit: EMC

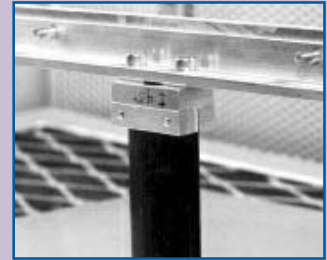
with a fully developed cross-section could be heated and rolled onto a spool. This would enable laying pipe lengths of 1,000 feet or more instead of lengths of 20 to 40 feet and reduce the number of joints required. Light emer-



1



2



3

applies force more gradually than shape memory alloys, so there is less risk of damage from shock to delicate mechanisms.

The flexibility and light weight of EMC makes it highly desirable for space-based applications. As part of the Phase II BMDO SBIR contract, CTD and its partners plan to subject an EMC hinge to a rigorous set of flight qualification tests and to qualify the material itself for use in space. Currently, in other work, CTD is testing some of its early EMC formulations onboard the International Space Station. In theory, EMC could be used to replace some components that currently apply force by means of motors, gears, and springs—all of which are subject to breakdown or malfunction.

Space is not the only place where EMC could be used. Composite pipes, for example,

agency shelters with no metal at all (and possibly no radar signature) could be transported to the battlefield and deployed immediately, then compacted and redeployed later. CTD is open to inquiries from interested parties who might have ideas for potential applications and would like to learn more about EMC capabilities.

—A. Gruen

CONTACT INFORMATION:

Michael Tupper
Composite Technology Development, Inc.
1505 Coal Creek Drive
Lafayette, CO 80026
Tel: (303) 664-0394
Fax: (303) 664-0392
E-mail: mike@ctd-materials.com
Web: www.ctd-materials.com



Bend and stretch. A hinge made out of elastic memory composite material starts out folded (1) but expands when heated (2) and then cools to return to its original shape (3).

NEW OPTICAL AMPLIFIER COMES IN SMALLER PACKAGE

A fiber amplifier almost nine times more compact than those sold today may enable

network providers to offer affordable fiber-to-the-home.

With help from BMDO funding, NP Photonics, Inc. (Tucson, AZ), developed and has an exclusive license to a patent filed by

the University of Arizona on a new erbium-doped fiber amplifier (EDFA) that offers high gain per unit length of fiber-optic strand. NP Photonics' product, which the company calls an erbium micro fiber amplifier (EMFA), is 7- to 8-cm long compared to a traditional amplifier containing up to five meters of looped cabling. The shorter length of fiber will make the packaging of amplifiers easier and 3- to 10-times less expensive.

NP Photonics' EMFA product is an outgrowth of work performed under a current BMDO SBIR Phase II contract and earlier BMDO SBIR-funded efforts dating back to 1998. Both current and past contracts emphasize a range of improvements in fiber-optic technology including lossless beam splitters and low-cost laser pumps. The general objective is both to increase the amount of bandwidth that can be managed and to route it within a smaller volume.

The secret of the amplifier is a novel erbium doping process that allows optical

gain on the order of 2 dB per centimeter of fiber. NP Photonics makes its own glass in its own facilities and incorporates this high-gain fiber into its amplifier product.

The advantages of short, high-gain fiber are twofold. It allows for a smaller total package, and it more easily supports multiport technology. A standard EDFA unit on the market measures 150 x 150 x 15 mm; NP Photonics' EMFA will measure 90 x 35 x 12 mm, or almost one-ninth the volume of a typical unit. Furthermore, currently all amplifiers work on the principle of one laser pump per fiber. However, if one pump could serve 4, 8, or 16 fibers by means of beam-splitting (the whole technique is called a multiport array), more bandwidth could be routed through a smaller space. In contrast, the packaging of multiple 5-meter-long cables into one amplifier would be extremely difficult.

NP Photonics plans to make its new EMFA unit available by mid-2002. In contrast to traditional amplifiers that are priced at any-

where from \$3,000 to \$10,000, the company could sell its units for as low as \$1,000 per port. NP Photonics has several customers waiting to test samples and plans to incorporate feedback about the new units in a second-generation release that should include multiport technology.

Telecommunications providers who want to bring high-speed broadband access to residences and offices will greatly benefit from smaller optical amplifiers. In cities and other densely populated areas, where installation space is at a premium, the cost advantages are apparent. NP Photonics invites interested parties to contact the company directly.

—A. Gruen

CONTACT INFORMATION:

Daryl Eigen
NP Photonics, Inc.
UA Science & Technology Park
9040 S. Rita Road
Tucson, AZ 85747
Tel: (520) 799-7486
Fax: (520) 799-7403
E-mail: eigen@np Photonics.com
Web: www.npphotonics.com



Small size, high gain.

NP Photonics' innovation is a full-featured erbium-doped fiber amplifier; also shown, a basic gain element and pump/coupler module.



Installing metro networks. Where space is at a premium, smaller amplifiers will enable network providers to install more capacity for less money.

FOR SIGNAL ISOLATION, MAGNETIC BEATS OPTICAL

Optical isolators are showing their age. Unlike other components on modern circuit boards, which have become ever smaller, these devices still take up a lot of space. They also are slow and operate in a limited temperature range. Newer technology is needed, design engineers say.

The solution may lie in magnetics. NVE Corporation (Eden Prairie, MN) has developed giant magnetoresistive (GMR)-based isolators that offer better performance than optical isolators for the same cost. The company was significantly helped by research it conducted for BMDO's SBIR program to explore the use of magnetic random access memory (MRAM) for data storage applications.

With speeds up to 100 megabaud (Mbaud), GMR isolators transmit data 4- to 20-times faster and have correspondingly faster rise, fall, and propagation times than their optical brethren. These devices also are 20-percent smaller and draw $\frac{1}{2}$ to $\frac{1}{3}$ less power. With regard to noise immunity and temperature stability, NVE's devices perform better. They operate up to 25 kV/ μ s and are stable at 100°C, compared with 10 kV/ μ s and 75°C for optical isolators.

NVE offers a product family of IsoLoop™ GMR isolators, which are ideally suited for industrial data bus, analog to digital conversion, and telecommunication applications. This family includes

single-channel, dual-channel, and four-channel devices (unidirectional and bidirectional). An isolated RS485 chip is also available. The single and dual-channel isolators are available in 9-pin DIP and 8-pin small outline integrated circuit (SOIC) packages. The four-channel version and the RS485 interface IC are available in wide-body 16-pin SOIC packages.

Distribution channels for NVE's GMR isolators have been established in Europe, Japan, Korea, China, and Taiwan. NVE has also teamed with Digi-Key Corporation, one of the fastest-growing electronic component distributors in the United States. "In the domestic market, Digi-Key is among the top 15 of the more than 800 electronic distributors and has done business with 99 of the top 100 electronic companies," commented Dr. Daniel A. Baker, NVE's president and chief executive officer. "This agreement is a great endorsement of NVE's new components and a key element of our strategy to dramatically broaden our component distribution."

Under a current BMDO SBIR Phase II project, NVE is developing faster, more rugged GMR isolators by combining a novel thin-film linear spin valve structure and low-voltage differential signaling (LVDS) circuitry. The spin valve structure is well-suited for high-speed operation because it is never driven to saturation. Hence, smaller

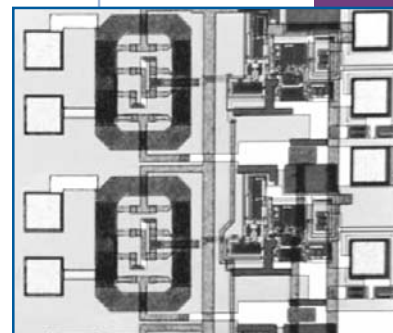
fields/currents can be used to switch the electronics. Using this design, NVE believes it can reduce the isolator's current usage from 50 to 10 milliamps, yielding a corresponding increase in speed from 100 to 500 Mbaud. The company recently demonstrated a prototype with speeds up to 300 Mbaud. The magnetic core of the spin valve structure is also more radiation tolerant than optical isolator cores.

NVE seeks private companies and military organizations interested in exploring potential applications for its GMR isolator technology.

—P. Hartary

CONTACT INFORMATION:

Bob Schneider
NVE Corporation
11409 Valley View Road
Eden Prairie, MN 55344-3617
Tel: (952) 829-9217
Fax: (952) 996-1600
E-mail: bobsch@nve.com
Web: www.nve.com



Small footprint. NVE's four-channel isolator chip in the photomicrograph has a footprint of only 2.1 mm². Because the device takes up less real estate on the board, there is more room for other functions.

Licensing is a key component of NVE's business plan. Current licensees include Motorola, Agilent Technologies, Cypress Semiconductor, Honeywell International, and Union Semiconductor Technology Corporation.

"A successful tool is one that was used to do something undreamed of by its author."

S.C. Johnson

SHARE THE DATA, BUT KEEP IT PRIVATE

Two financial organizations with thousands of branch offices want to cooperate to prevent fraudulent intrusion

into their computer systems. The problem is, they don't want to share their data with each other for competitive business reasons.

A new software tool called InferAgent™ that mines distributed data without moving or sharing it could be a boon to companies with data privacy concerns.

With BMDO SBIR funding, Datamat Systems Research, Inc. (McLean, VA), has developed its InferAgent technology to analyze data stored in different formats and at different locations and extract useful information from it. Today's data mining tools are limited because the distributed databases must be combined on a single workstation for the tools to centrally collect and share data. That can be a problem for data owners—particularly those with sensitive data—who are interested in sharing the results, but not their data.

InferAgent controls the integrity of local data sources, yet passes their correlated knowledge through to decision makers without the need for the data itself. The technology relies on independent software agents installed at every distributed database location. Each "intelligent"

agent only has access to its own local database and is responsible for obtaining information from that local data source. A Java-based tool called Mediator synchronizes the collection of information from each location and generates global models. A 3-D visualization capability helps decision makers recognize and understand the discovered relationships and patterns presented by these models.

Datamat developed this software under BMDO SBIR Phase I and II contracts. Mobile command posts must have accurate, real-time knowledge of friendly, enemy, neutral, and noncombatant activities and locations. As the amount of data available explodes, and its availability comes from physically and logically distinct sites, the need arises for distributed and compatible access. Datamat's technology can integrate data from different land, air, and sea components, distribute them throughout a global communications grid to command posts, and present them in an optimal way. These capabilities do not currently exist.

Law enforcement and domestic security agencies, such as the CIA, FBI, and U.S. Customs, will be very interested in InferAgent technology. In the continuing war on terrorism, these groups will require more collaborative sharing of agency-specific intelligence. InferAgent can be used to analyze intelligence across various agencies for making observations and decisions not possible using a

single agency's database. Like personnel, weapons, and ordnance, information will become a vital command resource.

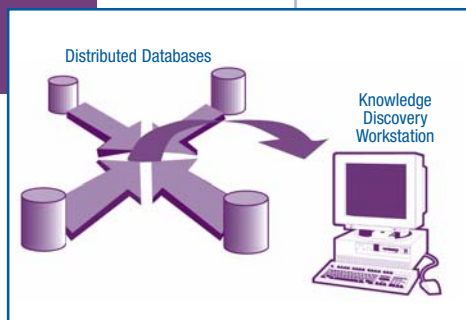
InferAgent can also be customized for a wide variety of corporate applications requiring collaboration and decision-making. For example, health care institutions could work together to detect fraudulent claims and financial companies could team up to uncover transactions that match patterns indicating potential criminal activities. Network security is another possibility. Datamat is discussing a potential licensing agreement with national network operator that is looking at InferAgent to detect security breaches.

InferAgent is now available for demonstration. Federal agencies that procure the software before September 30, 2002 won't be charged a licensing fee. InferX Corporation, a spin off company, is responsible for the technology's commercialization. InferX seeks inquiries from organizations interested in exploring new applications for InferAgent technology. Also being sought are venture capital and high-profile members for the company's board of directors.

—P. Hartary

CONTACT INFORMATION:

B.K. Gogia
Datamat Systems Research, Inc.
8260 Greensboro Drive, Suite 120
McLean, VA 22102
Tel: (703) 917-0880, ext. 225
Fax: (703) 917-0563
E-mail: bkgogia@dsri.com
Web: www.inferx.com

**Care to share?**

Datamat's InferAgent technology doesn't move the data to mine it. Instead, it uses independent software agents to collaborate and discover knowledge across all distributed database locations.

QUICK-THINKING SILICON BRAIN IN THE WORKS

Imagine breakfast in the morning—it takes you only an instant to recall the sound and smell of bacon and eggs frying, the sight of a tall glass of orange juice, the taste of warm butter on toast, and the touch of fluffy pancakes. An effort is currently underway to design a neural network that can remember and identify images just as quickly.

Irvine Sensors Corporation (Costa Mesa, CA) is leading a collaborative effort to create a neural network the size of a shoebox with the same volumetric efficiency as the human brain. Other team members include the California Institute of Technology, Jet Propulsion Laboratory, University of California San Diego, University of Southern California, and Boston University.

Irvine Sensors is incorporating its 3-D Artificial Neural Network™ (3DANN) and 3-D Field-Effect Transistor Interconnect Technology (3DFET) into the Silicon Brain. BMDO funded the Silicon Brain for capabilities in executing sensing, discrimination, and systems control functions of ballistic missile defense. Irvine Sensors' 3DANN technology is a sugar-cube sized stack of custom neural chips connected to stacks of field programmable gate arrays (FPGAs) and memory chips. The 3DFET technology enhanced 3DANN by serving as the intermediate layer and the electronic interconnect between the FPGAs. The chip stack can provide petaflop performance (quadrillions of operations/second) using less than 10 watts of power. In

addition to the neural network hardware and chip-stacking technology, Irvine has written software to optimize 3DANN, which is then integrated with a sensor or sensor suite.

The Silicon Brain technology requires a method of acquiring and retrieving information. To fill this need, Irvine Sensors developed a concept called dynamic stare—a mimic of what the eye and brain do to create images when a person is staring. The eye has a saccadic motion and captures several overlapping frames of an image, then the brain reconstructs a higher resolution picture for the person to see. The company developed an algorithm capable of copying this process. The algorithm will be incorporated into 3DANN technology for the Silicon Brain, but it has also been developed into a software that can work on a conventional computer. The RedHawk™ image processing software operates on personal and Macintosh computers. It has been sold to police and security forces for forensic applications, but has been most successful in the consumer market for amateur photography.

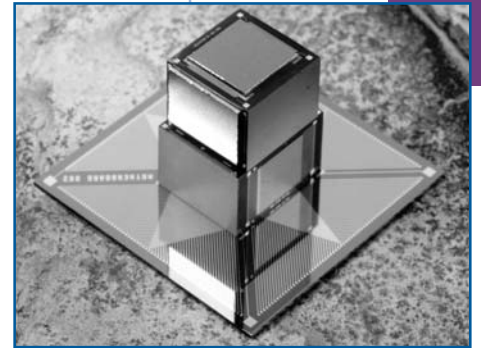
A combination of 3DANN, 3DFET, and superconducting chips contributed by TRW led to the development of the SuperRouter™, an extremely fast Internet router. iNet-works™ is a commercial outlet for the SuperRouter™, which compresses eight conventional 7-foot-high router bays into one. The product is still in development but the first production prototype will

be complete in less than a year and the company expects the product to be on the market in about 18 months. A potential market for the SuperRouter™ is the Internet2® K20 Initiative, which is intended to bring industry and academia

together “to get new technologies—advanced networking tools, applications, middleware, and content—into the hands of the innovators, across all educational sectors in the United States, as quickly and as connectedly as possible.”

The RedHawk™ software and SuperRouter™ hardware are the first two spinoff technologies from the Silicon Brain. Two more technologies are expected in a few years. Irvine Sensors is currently waiting on a Phase III proposal that will carry the technology into the development of human-like qualities, according to Dr. John Carson, senior vice president of Irvine Sensors.

—T. Spitzer



Think speed. An enhanced version of Irvine Sensors' 3-D Artificial Neural Network™ technology will allow the Silicon Brain to perform quadrillions of operations per second using less than 10 watts of power.

CONTACT INFORMATION:

Dr. John Carson
Irvine Sensors Corporation
3001 Redhill Avenue, Bldg. 111
Costa Mesa, CA 92626
Tel: (714) 549-8211
Fax: (714) 557-1260
E-mail: jcarson@irvine-sensors.com
Web: www.irvine-sensors.com

INSTANT-ON KILOWATTS

An emergency vehicle pulls up to a burning building at night. The crew needs electricity for lamps and power

tools, but in the time it takes to set up and operate a synchronous generator to run them, lives could be lost.

The solution may be at hand.

Raven Technology LLC (Brunswick, ME) has developed, with BMDO funding, an electric power generator that works without the use of inverters. The company's patented AC-Direct™ system connects to an engine and provides up to five kilowatts of household-type current almost instantly, regardless of shaft speed.

AC-Direct is the result of BMDO-funded research at Raven (formerly Dirigo R&D Inc.) to develop a lightweight and fuel-efficient mobile electric power generator. Under a 1997 Phase I SBIR contract, researchers proved the feasibility of a 120-volt, 60-Hz, two-kilowatt unit using a wave-shaping technique that modifies alternating current. Company engineers extended their efforts in 1999 under a Phase II award and developed prototype and fieldtest units with improved efficiency and higher output.

The secret to AC-Direct is what Raven designers call soft commutation. Operating con-

trol circuitry with very low (approximately 200-watt) power input, they modulate an alternator's electromagnetic field to control the output voltage. They strengthen the magnetic field up to a peak and then bring it back down to zero. With the current at zero, they quickly reconfigure the circuit, reverse the field, and achieve commutation. In effect, the system achieves the same output result as an inverter but does not, as normal inverters do, switch live current. This means the control electronics need weigh only about 5 pounds, not 50.

Firefighters need to be able to vary the speed of their vehicle's engine without the worry of draining battery power. AC-Direct runs at any engine speed and generates instant household-type current. Raven is working with a fire truck assembler and a local fire company to test a five-kilowatt unit, called the Blackbird, under actual conditions. Raven also has been testing a Blackbird in partnership with an air compressor

leasing company. Air compressors are variable speed and provide ample space, which enables easy installation and access.

Providing single-phase, 120-volt, 60-Hz AC power might have military applications including use in field hospitals, temporary command outposts, and airfield emergency rescue vehicles. Some Maine National Guard organizations have expressed interest in testing Blackbird units, but the partnership idea foundered against regulations prohibiting state modification of Federal equipment. Raven is thus very interested in finding U.S. armed services partners to help beta-test Blackbird units under actual field conditions.

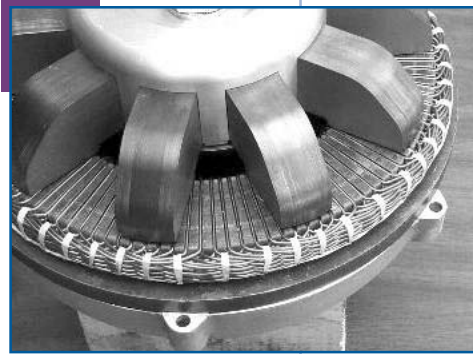
—A. Gruen

CONTACT INFORMATION:

Christopher Tupper
Raven Technology LLC
14 Industrial Parkway
Brunswick, ME 04011
Tel: (207) 721-1044
Fax: (207) 798-5060
E-mail: raven@raventechpower.com
Web: www.raventechpower.com



Saving lives. The Brunswick, ME fire department is eager to install AC-Direct™ in Engine No. 3. The power generator can provide extra electricity for lamps and power tools, which can aid in rescue operations.



Get wired. Wire wound within the alternator enables control circuitry to modulate the electromagnetic field and control the output voltage.

GO WITH THE FLOW, WITHIN MILLISECONDS

How good is the new generation of spacecraft propulsion system microvalves? These valves can precisely control gas flows smaller than what used to be considered leaks.

Marotta Scientific Controls, Inc., (Montville, NJ), has patented a multifunction valve (MFV) that uses a smart metal alloy in a magnetostrictive actuator to open and close a low-flow, small aperture gas valve within milliseconds. This allows designers to precisely modulate pressure and regulate flow in thrusters that could help make satellites last years longer in space.

From 1995 to 1999, BMDO funded Marotta with Phase I and II SBIR contracts for a valve design that would improve performance and lower the weight of spacecraft propulsion systems. Ion thrusters and Hall Effect thrusters operate at very low thrust (less than 200 millinewtons) and require a low xenon gas flow rate controlled by a valve stroke measured in microns. The need for a small stroke plus the need to keep leakage to a minimum argued in favor of a smart metal alloy actuator that could be turned on and off quickly and yet provide high closure force. The result was a design for a MFV that worked at pressures up to 2000 psi.

The heart of Marotta's MFV is a smart metal alloy called Terfenol-D® made by Etrema Products, Inc. This material, a blend of terbium, iron, and dysprosium-D, changes its shape when the magnetic field that surrounds it changes. Wrap a solenoid

coil around the metal and run a current through the coil, and the metal expands and drives a poppet. This can be done hundreds of times per second with variable force depending upon the current input into the coil. Marotta's special design includes all-metal construction to maintain purity of the xenon gas.

Since 1999, Marotta engineers translated the design concept into production reality, although MFVs are currently available only in small quantities. Marotta has potential customers eagerly awaiting test results to find out exactly how many cycles per second a typical valve opens and closes, how much power it consumes, and other specifications. Marotta is working closely with Pratt & Whitney to integrate a MFV into their electric satellite propulsion system design.

The MFV could work in any environment that needs small but nearly continuous flow rates. Consider, for example, undersea oil drilling in situations where chemicals might need to be injected to prevent corrosion or paraffin buildup. The company invites inquiries from interested parties who might have a need or application for an MFV.

—A. Gruen

CONTACT INFORMATION:

Kurt Black
Marotta Scientific Controls, Inc.
78 Boonton Avenue
Montville, NJ 07045
Tel: (973) 334-7800
Fax: (973) 334-1219
E-mail: kblack@marotta.com
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VIDEO/CD EXPLAINS ALL TO
MDA-FUNDED ENTREPRENEURS

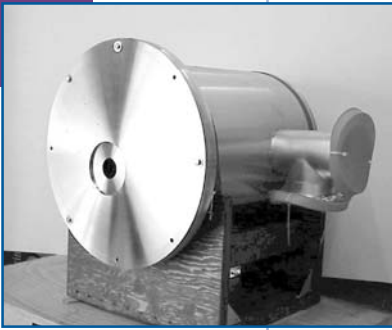
Attention MDA-funded researchers: Many of you may not be aware of the commercialization services available to you free-of-charge through the MDA Technology Applications program. All MDA-funded researchers—even those who have not received funding from our organization in years—have free access to mentoring, business development, and outreach services to commercialize the technology and products that have resulted from MDA-funded research. Whether you are an early stage developer or already have a prototype, these services can help you develop strategic partnerships, define a business strategy, obtain needed guidance from experts with records of success, and attract capital to scale up your technology for commercial and defense use.

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For a free copy, call (703) 518-8800, extension 500. Leave your name, mailing address, and telephone number. Please indicate whether you would like to receive the video OR the CD.



Countering Terrorism . . . from page 1



Fast detection.

Kestrel's ultraspectral imager can detect most chemical contaminants in near real-time. With fast chemical detection and identification, emergency response teams can more quickly administer the correct medical treatment to the injured.

allowing it to run continuously for long periods of time.

The ultraspectral imager is currently being validated in laboratory measurements and will be ready for field demonstra-

tions during late summer 2002, according to Dr. John Otten, corporate technology officer for Kestrel.

3-D Face Identification System

Terrorists are hard to spot. Law enforcement agencies can not be everywhere at once, so finding terrorists will require advanced imaging technology capable of biometric measurements. Biometrics, the measurement of physical characteristics or personal behavior traits to establish identity, can find a single face in a crowd.

Genex Technologies, Inc. (Kensington, MD), is marketing a 3-D face identification system called 3D FaceID™ that can use biometric measurements to compare constant, distinct facial features with suspects' images in a database.

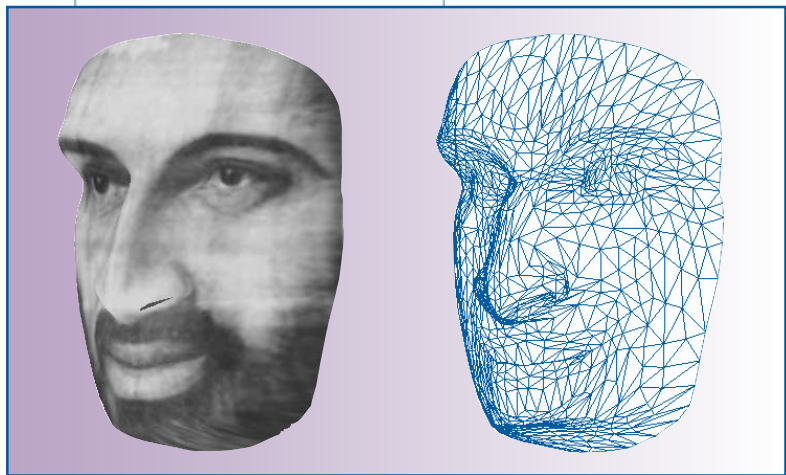
The system is based on the Rainbow 3D® Model 250 camera, which captures full facial images for facial recognition, in two and three dimensions simultaneously in real-time. The BMDO SBIR program funded Genex's 3-D imaging technology to enhance battle management

by allowing personnel to view a missile's trajectory in 3-D space. The camera has a field of view of 250 x 200 millimeters with an accuracy rating of 250 microns, which is approximately the size of the period at the end of this sentence. The technology is based on a structured light process and captures over 440,000 data points of information.

The 3D FaceID system is packaged complete with a Pentium 4 computer and software for capturing, viewing, and saving the images. A database of 3-D images is needed for this technology to be useful. "Genex's short-term goal is to protect secure areas in the nation's airports," said Patrick May, director of sales and marketing for Genex. Anyone with clearance into a secure area

3-D image on file. The key to this technology is that it is unobtrusive and passive—it does not require any action by the suspect.

A long-term goal is to use the 3D FaceID system nationally to prevent suspected terrorists from entering the United States in the first place. One avenue Genex is considering is to install the camera in visa and passport offices. Everyone who obtains a visa or passport would be required to file a 3-D photograph into a national database. Eventually, it would be ideal for an international system to be implemented to restrict the movement of suspected terrorists and criminals from country to country. This goal would require an international database of images similar



Face off. *For many years, terrorists have been biding in plain sight. Now, with the introduction of Genex's 3D FaceID™ system, law enforcement has a greater chance of finding them. The system, which compares over 440,000 data points of information, can match images of suspected terrorists in just a few seconds.*

would have a personal 3-D image stored in the database. The 3D FaceID system would then identify as an intruder anyone who does not have a

to the FBI's Integrated Automated Fingerprint Identification System which, with 42.8 million digitized records,

Continued on page 15

Countering Terrorism . . . from page 14

is the largest database of criminal fingerprints in the world.³

The 3D FaceID system prototype is currently in testing, which has been successful, and should be available in six months to one year.

Financial Security Software

Terrorist organizations may have different ideologies, cultures, and causes, but they all have one thing in common—money. That money has to come from somewhere, which means there is a money trail. Finding that trail can lead to stronger cases against alleged terrorists. Investigators recently linked Zacarias Moussauoui and other hijackers to a money trail leading to the United Arab Emirates and Pakistan.⁴

HNC Software (San Diego, CA) launched its Risk Manager for Money Laundering system at 5:00 a.m. on September 11. Risk Manager uses a combination of neural network and statistical models to examine transactions and detect money laundering activity. The company developed for BMDO early neural network technology to compress and decompress data in near real-time using low-cost hardware.

The software provides a flexible framework to utilize profiling analysis. “The key problem is sifting through large amounts of data, looking for a very few high-risk indi-

viduals or events,” says Todd Gutschow of HNC.⁵ Risk Manager profiles transaction patterns at the account, customer, and peer group levels, including type of customer, geographical area, branch, and other categories. These profiles provide a baseline for normal behavior, against which each transaction is evaluated during the monitoring process. The technology then builds on the customer profiling information with intelligent statistical models to identify high-risk customers and accounts. Risk Manager can evaluate millions of transactions a day for potential money laundering activity based on established automated money laundering models and rules. HNC’s Risk Manager technology is currently available for use.

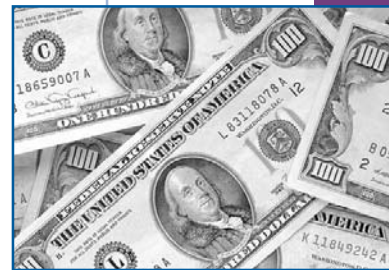
Impeding terrorist cells’ money flow is one effective way of halting, at least momentarily, their actions. Risk Manager also allows investigators immediate access to all data on suspicious transactions.

CONTACT INFORMATION:

Dr. L. John Otten
Kestrel Corporation
3815 Osuna Road NE
Albuquerque, NM 87109
Tel: (505) 345-2327
Fax: (505) 345-2649
E-mail: ljotten@kestrelcorp.com
Web: www.kestrelcorp.com

Dr. Jason Geng
Genex Technologies, Inc.
10605 Concord Street
Suite 500
Kensington, MD 20895
Tel: (301) 962-6565
Fax: (301) 962-6555
E-mail: geng@genextech.com
Web: www.genextech.com

Melinda Bateman
HNC Software, Inc.
5935 Cornerstone Court West
San Diego, CA 92121
Tel: (858) 799-8370
Fax: (858) 799-3831
E-mail: mb@hnc.com
Web: www.hnc.com



Follow the money. HNC’s Risk Manager for Money Laundering software can help investigators link terrorists to their funding sources by identifying and tracking money trails.



TECHNOLOGY REPORT AVAILABLE

A report featuring 18 MDA-funded technologies with counter-terrorism applications is now available. The report has three sections: chemical and biological countermeasures, surveillance and information collection, and cyberwarfare. The technologies featured in the report are currently or will soon be on the market. To order your free copy of the report, call (703) 518-8800, ext. 500. Leave your name, mailing address, and telephone number. The report can also be viewed online at www.mdatechnology.net.



³Kirkpatrick, Michael. 2001. How New Technologies (Biometrics) Can Be Used to Prevent Terrorism. Statement for the Record Before United States Senate Committee on the Judiciary Subcommittee on Technology, Terrorism, and Government Information, Washington, DC, November 14.

⁴Candiotti, Susan. 2002. Unanswered Questions Remain in September 11 Probe. CNN (online), March 11.

⁵Bigelow, Bruce. 2002. Computers Try to Out-Think Terrorists, *San Diego Union Tribune*, January 16.

MDA *Update*

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- NANORIZED METALLIC POWDERS

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MDA *Update*

**Learn how missile defense
technology can help strengthen
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